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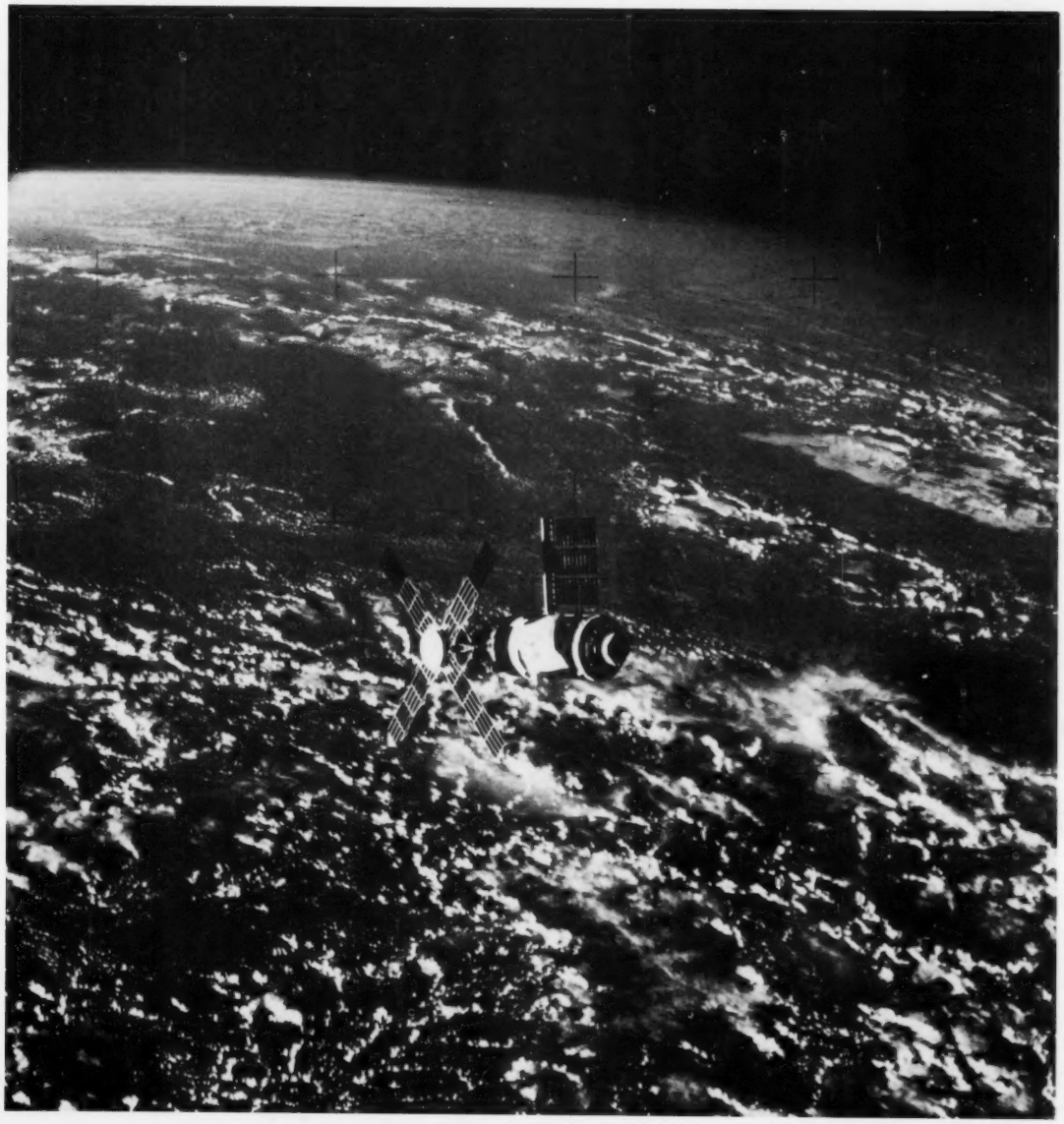

About the Cover

View of the 100-ton Skylab space station in orbit around the Earth, taken from the command module of Skylab 2 during a final fly-around inspection of the station. The Skylab 2 mission, launched May 25, 1973, was the first manned mission of the project. The three–man crew—Charles Conrad, Jr., Paul J. Weitz, and Joseph P. Kerwin—completed 404 revolutions of the Earth and conducted three EVA's (extravehicular activity) totalling over 5 hours, 30 minutes, during which repair of the Skylab 1 orbital workshop was completed. The crew also conducted 392 hours of experiment work while in orbit. Mission duration for Skylab 2 was 28 days, 3 minutes.

During launch of Skylab 1 on May 14, 1973, dynamic forces sheared off the meteoroid shield and one solar array wing of the station. Another solar wing was snagged in the folded position. This damage was repaired by the crew of Skylab 2.

The Skylab 2 mission was followed by two more three-man crews during 1973: the Skylab 3 crew, Alan L. Bean, Jack R. Lousma, and Owen K. Garriott, spent 59 days in space; the Skylab 4 crew, Gerald P. Carr, William R. Pogue, and Edward G. Gibson, spent 84 days in space. Each mission set a new duration record for the United States for manned spaceflight.

The Skylab missions proved man could live and work in space for extended periods and that expanded solar astronomy data, beyond that previously collected from Earth-based observations, could revise our understanding of the Sun and its effects on the Earth. The Skylab missions also returned much information from surveys of Earth resources taken with new remote-sensing techniques.

The deactivated Skylab 1 orbital workshop reentered the Earth's atmosphere on July 11, 1979.

The NASA historical calendar of events for the month of May appears on page 26 of this issue.

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Administrator's Column

(In this column, *NASA Activities* features an article by NASA Administrator James M. Beggs. These articles focus on subjects chosen by him that address topics of broad interest to agency employees).

NASA Productivity Improvement and Quality Enhancement Program

As long as there have been employer/employee relationships in business, productivity has been a concern: if improvement is needed, how to increase it, or if the level is satisfactory or exceeds expected goals, how to maintain it. But also inherent with emphasis on productivity is a corresponding interest in quality—an increase in productivity is only effective if quality of the work or product is retained or, ultimately, improved.

NASA, as one the nation's foremost research and development agencies, has established a reputation for superior productivity and high quality, even under severe budgetary and manpower constraints. Recognizing that such conditions are likely to become increasingly severe in the years ahead, NASA formed a Productivity Steering Committee last July to develop an agency-wide approach to productivity and quality that would provide, in the long term, the best possible work at the highest level of quality under the constraints of a constant work force and tighter budget.

Implementation of NASA's Productivity Improvement and Quality Enhancement Program will focus on seven goals:

- heightening management and employee knowledge and awareness on productivity and quality enhancement approaches;
- encouraging management practices and the use of new technology to increase productivity;
- broadening employee participation in management decisionmaking;
- establishing processes for defining productivity and productivity measurement gauges at each organizational level;
- identifying impediments to productivity and quality enhancement and the opportunities for greater productivity;
- developing approaches and incentives for project and contractor productivity advances; and
- communicating objectives, approaches, and results of center productivity and quality enhancement efforts to NASA employees and managers.

But in order for this program to work, management and employees must strive cooperatively toward achievement of these measures. *The key to productivity and quality is motivation and commitment; the principle is recognition and reward.*

NASA's agency-wide effort is decentralized in its implementation and centrally coordinated by the NASA Productivity Improvement and Quality Enhancement Steering Committee formed last July.

Members of this committee include, in addition to myself, the Deputy Administrator, the Associate Deputy Administrator, Comptroller, Chief Engineer, Chief Scientist, Associate Administrators for all NASA's major program areas, and the Center Directors. David Braunstein of NASA Headquarters is acting as the Executive Director of the Committee and head of NASA's Productivity Improvement and Quality Enhancement Program.

The Steering Committee first met in January in Pittsburgh at the Westinghouse Electric Corp., to review their Productivity and Quality Center and discuss with them information on productivity concepts that have proved successful for Westinghouse such as quality circles, computer-aided engineering and office automated systems. The next meeting of the NASA Productivity Steering Committee is scheduled for June 8th and 9th and will be held at TRW Space and Technology Group, Redondo Beach, Calif.

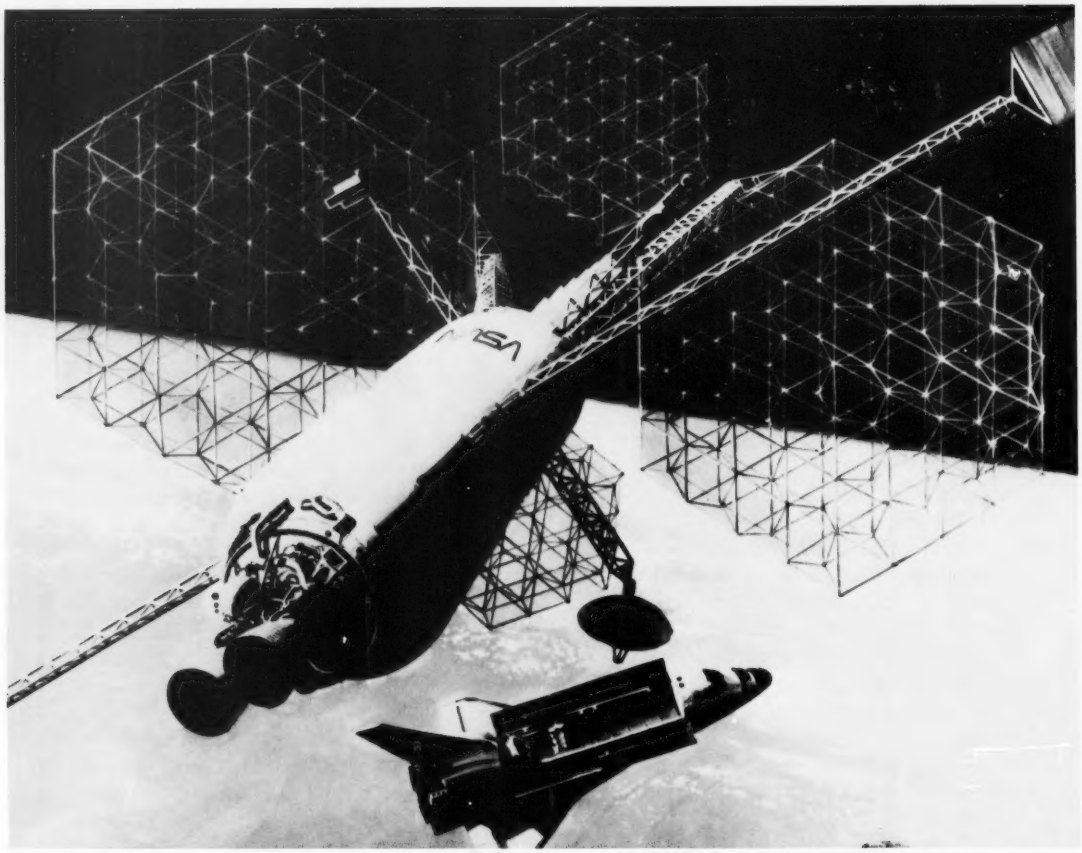
In addition to NASA's central committee, productivity coordinator networks and working groups have been formed at Headquarters and the centers to begin specific initiatives for each of the goals previously listed.

The January steering group meeting also focused in on the agency activities currently being carried out by each of the centers and Headquarters to increase productivity. These activities were summarized for discussion under four major categories: human resources, managerial practices, operational systems and program planning and execution.

Under human resources, several organizations indicate their programs strive to encourage participative management, improve employee recognition and reward processes, and enrich employee development and training resources. As for managerial practices, goals have been established to achieve increased delegation of authority, optimal use of current workforce and available resources; simplification of workload by elimination of waste and/or duplicative effort and, perhaps most important, the creation of better, effective communication (dialog) with employees.

Operational systems included under NASA's Productivity Improvement and Quality Enhancement Program have an agency-wide emphasis on interactive computing systems, increased automated data processing and office automation; improving research and development facilities in aeronautics and space and reducing cost for the Space Transportation System.

Improving NASA's productivity and quality is a high priority NASA objective. There will be no instant formulas for achieving these goals and the use of a single approach at all centers is not realistic. Thoughtful analysis and application of varying approaches and plans tailored to individual center needs, however, will make a difference. In order to establish an agenda to actively guide the productivity and quality enhancement program, a survey was conducted at the centers to identify possible areas of productivity inhibitors to program planning and execution.



Future Rocket Booster—Artist concept of NASA-developed Centaur upper stage, designed to carry heavy payloads into higher orbit once deployed from the Space Shuttle. In this illustration, the Centaur has been ejected from the Shuttle and is about to boost to geosynchronous orbit a communications satellite platform.

The areas cited in the survey were management planning, budget planning and execution, management practices, procurement, paperwork, program operating plan, research and technology operating plan processes, funds for modernization and personnel practices. Efforts will be made to examine each of these areas to see what can be done to improve our planning, communications and decisionmaking processes.

Work already has begun agency-wide on resolving some of the productivity inhibitors that includes establishment of agency-wide guidelines for promoting office and administrative automatic data processing systems and streamlining of procurement activities.

NASA's Productivity Improvement and Quality Enhancement Program is new and, as such, is one that will continue to evolve and grow throughout the coming months. As the program evolves, specific initiatives will be set into place to achieve the seven program goals outlined in the beginning of this article. However, the collective impact of the working groups assigned to these specific initiatives can only be as successful as the active participation of management and employees at all levels within NASA.

One initiative that is of particular importance to all employees and will encourage involvement from most sectors within NASA is the concept of quality circles, called NASA Employee Teams (NETS). This month, several centers and headquarters offices will start initial training and management briefings of these teams.

The objective of this concept is to effectively involve employees in the decision-making processes and to provide an effective, efficient means of improving productivity by giving employees an active role in identifying and solving problems that impact on employee performance or product quality.

The quality circle concept is in itself not a new management technique, originating in industrial Japan in the 1950s as a means of ensuring manufacturing quality control. Today, as many as six million Japanese workers participate in quality circles. And in the United States, 37.4 percent of all general manufacturing industries (including aerospace) use the quality circle concept—and the rate continues to increase.

Some major U.S. companies or businesses that use quality circle concepts include: Westinghouse, General Electric, Rockwell International, Martin Marietta Aerospace, General Dynamics, Honeywell, Northrup, Hughes, General Motors, and American Airlines. Government agencies already actively employing quality circles include the U.S. Army, Air Force, Navy, and Coast Guard, the Defense Logistics Agency, Office of Personnel Management, National Institutes of Health, and the United States Postal Service. At NASA, the quality circle concept has been implemented at Goddard, Lewis and Langley.

Briefiy, a quality circle consists of a group of workers, generally from 5 to 10 people, from the same area or work discipline who agree to meet weekly to identify, analyze and solve problems of quality and production that affect them. The role usually follows this formula: circle members identify the work-related problems they wish to solve, ranking in order which problems to examine; gather data for analysis of the problem; and then evaluate and offer possible solutions. The results of their activities are conveyed to management in a combined oral and written presentation for response.

NASA Employee Teams (quality circles) are based on a two-fold belief: (1) that the people who perform the work are most aware of the quality and productivity problems, and (2) that they are willing and able to contribute their knowledge, creative ability, and skills to the improvement process if provided the opportunity, training and support. NASA Employee Teams encourage team building, allow members to develop their own problem-solving capabilities, and improve communications, motivation, morale and job satisfaction.

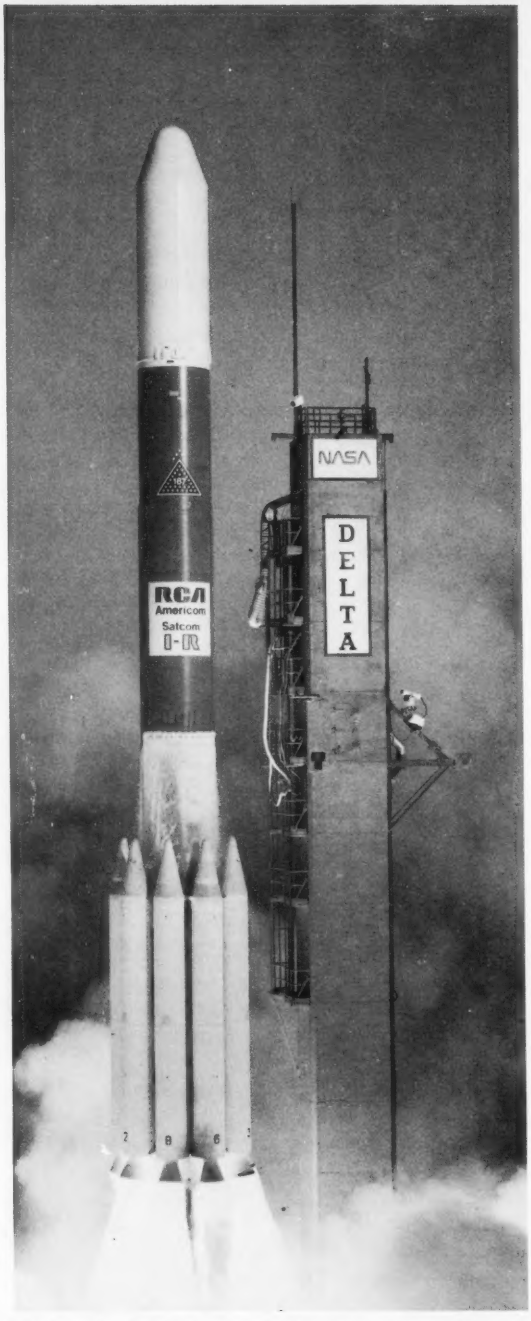
Target areas examined by industry quality circles have included: system process material defects; administrative processes or work flow; division of functions or tasks; staffing; communications flow; safety; training; and office arrangement or work locations. NASA Employee Teams will respond not only to these problem areas as outlined but to expanded additional concerns as defined by the team's initiating steering committee.

Quality circles are but one part of NASA's seven-prong plan for productivity improvement and quality enhancement. But the goal of broadening employee participation is of specific importance because it outlines one very important point and that is that the greatest resource of NASA or any organization is its people.

The key to achieving productivity improvement is through employee involvement in all phases of our activities, and quality circles represents one such method. While NASA's leadership role in research and development demands increased investment in technological advances, technology alone is not sufficient unless supported by productive, dedicated people. It takes people to put this new technology to work; people who are challenged and are willing to accept change and to embrace new ideas.

As a government agency concerned with our nation's aerospace preeminence, we must strive to improve our individual, organizational and national productivity. By increasing our own productivity and that of our contractors through the use of advanced technology and management innovation, we will be in a position to make a significant contribution to our nation's productivity in both the public and private sector.

I am confident that NASA's employees are willing to accept this challenge. One need only examine NASA's accomplishments over its brief 25-year history to be assured that the talent and the capability exists not only for our continued leadership in aeronautics and aerospace but also in productivity improvement and quality enhancement.



RCA Launch—Communications satellite RCA-F (Satcom 1R) was successfully launched aboard a Delta expendable launch vehicle at 5:39 p.m. EST, April 11. At left, the satellite undergoes pre-launch spin testing activity at the Delta Spin Test Facility at Cape Canaveral Air Force Station, Fla.

Space Shuttle Mission 6—Pictorial Highlights

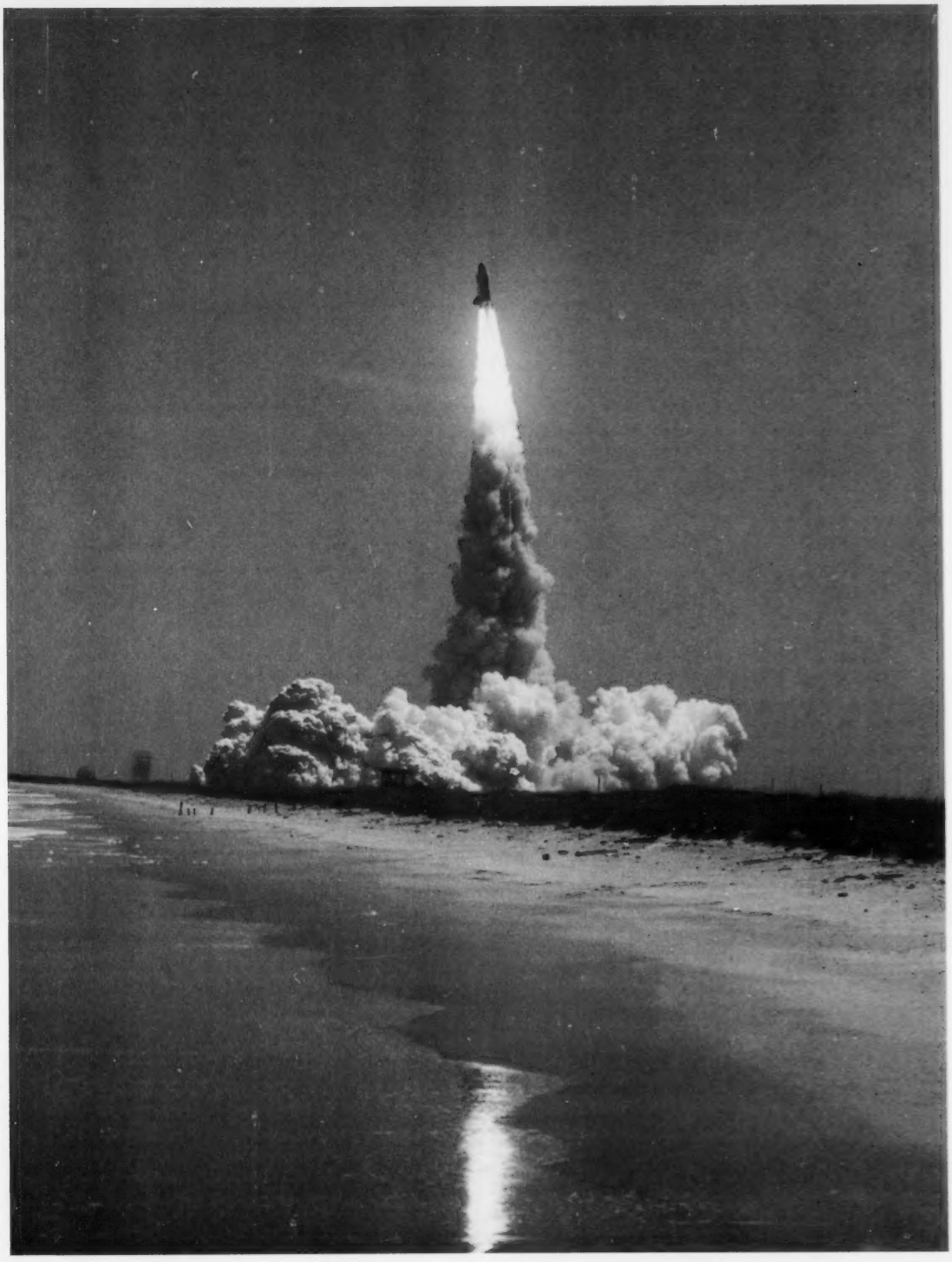
Crew	Paul J. Weitz, commander Karol J. Bobko, pilot Donald H. Peterson, mission specialist Story Musgrave, mission specialist
Orbiter	Challenger (OV-099)
Challenger arrival at Kennedy Space Center	July 5, 1982
Time in Orbiter Processing Facility	July 6–Nov. 23
Rollover to Vehicle Assembly Building	Nov. 23
Rollout	Nov. 30
Launch date and time	April 4; 1:30.884 p.m. EST
Launch site	Kennedy Space Center, Fla. Launch Pad 39A
Landing date and time	April 9; 1:53:49 p.m. EST
Landing site	Edwards Air Force Base, Calif. Hard surface runway 22
Mission duration	5 days, 23 minutes, 42 seconds
Orbits	79 full orbits; deorbit burn for reentry on 80th orbit
Payload deployment	TDRS-A; deployed 4/4/83; 11:31 p.m. EST
EVA (Extravehicular Activity)	April 7 (flight day 4) 3½ hour duration; 4:15-7:45 p.m. EST

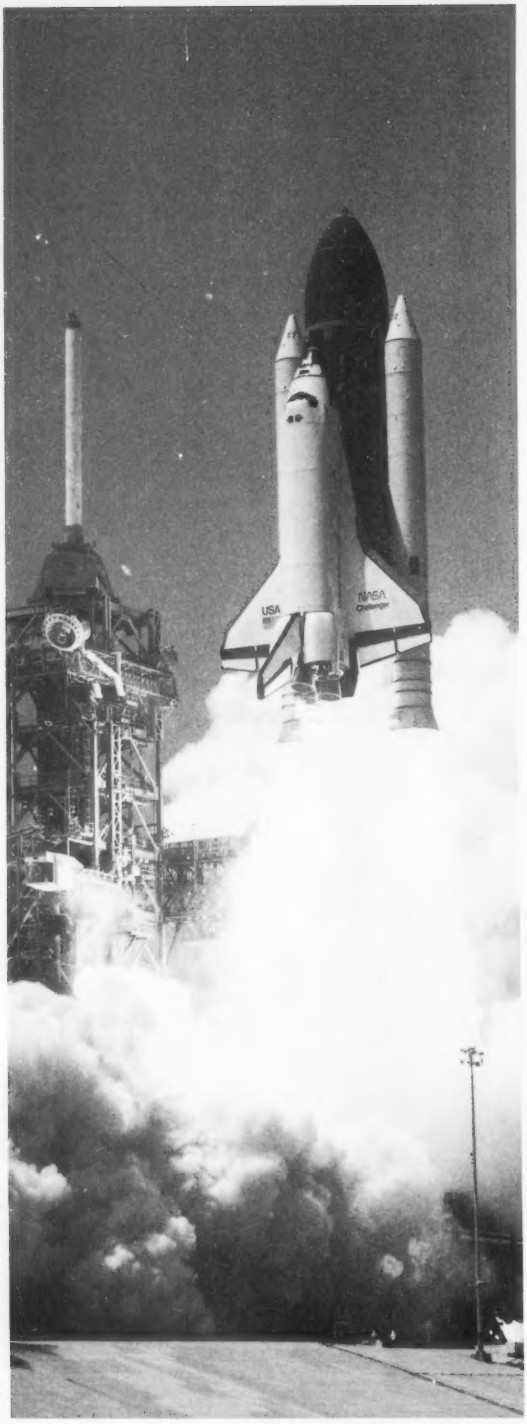
Pre-Launch Activities—Thousands of people await the first launch of NASA's second orbiter, Challenger, on April 4 (p. 7). Total Kennedy Space Center on-site crowd was estimated at 34,000.

Rockwell technicians assist Shuttle 6 crew members, Story Musgrave (top left) and Karol Bobko (bottom left), in pre-ingress. in the "white room" surrounding the orbiter hatch area.

Crew breakfast on launch morning (top right); crew departs Kennedy's Operations and Checkout Building for Launch Pad 39A (bottom left), eager to begin the sixth Space Shuttle mission.

Launch of Space Shuttle Challenger on April 4, 1983 at 1:30:.884 p.m. EST. With this liftoff, NASA acquired the basis for its orbiter fleet, adding a second Space Shuttle to its operational goal of four orbiters. The STS-6 countdown of 93 hours running clock time and 26½ hours hold time proceeded trouble-free to liftoff. Despite the pre-countdown problems with the Space Shuttle main engines, Challenger's launch and ascent to final orbit was performed nominally.




USA
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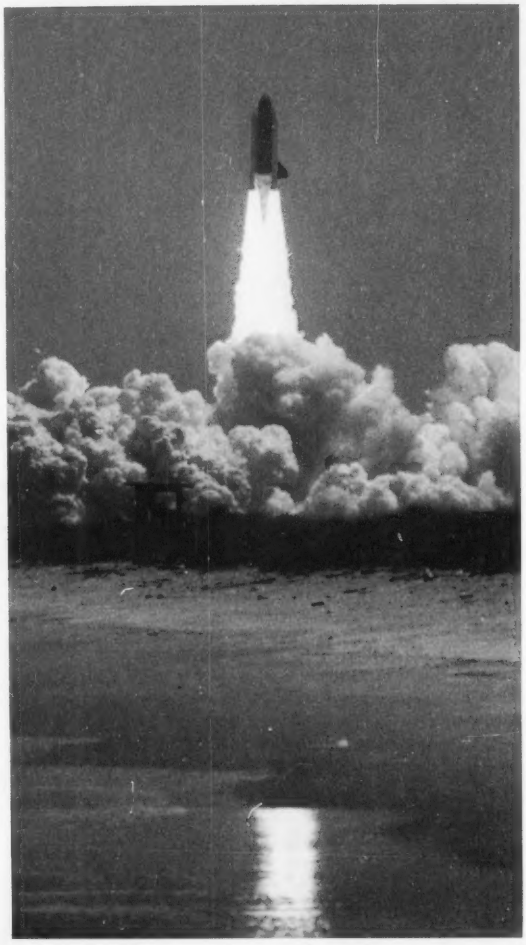
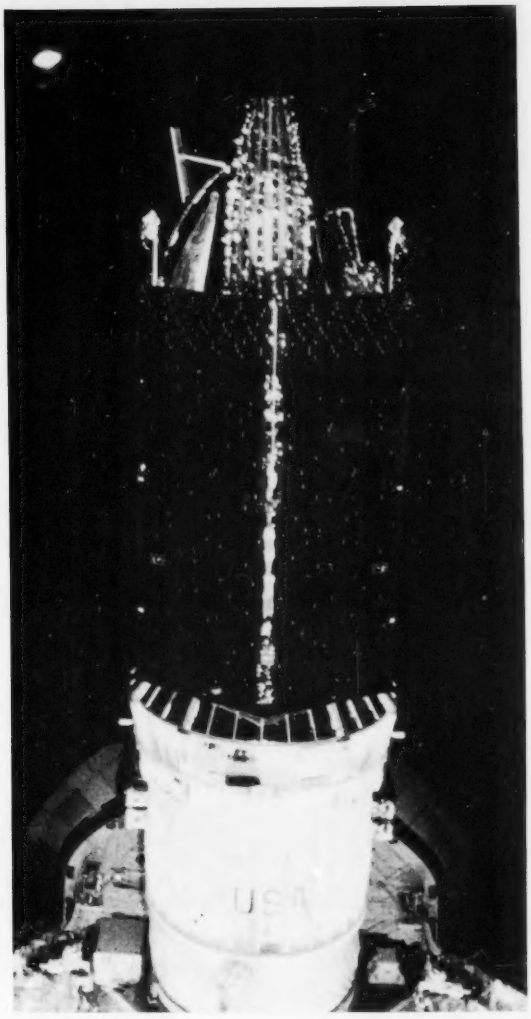
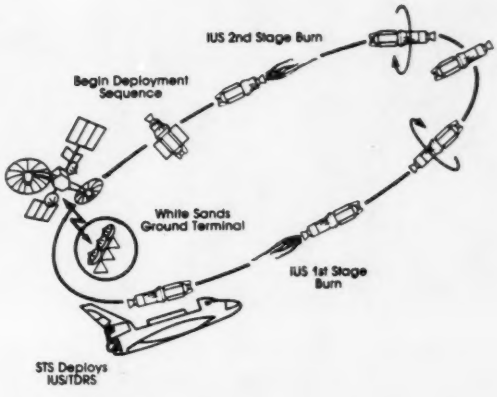
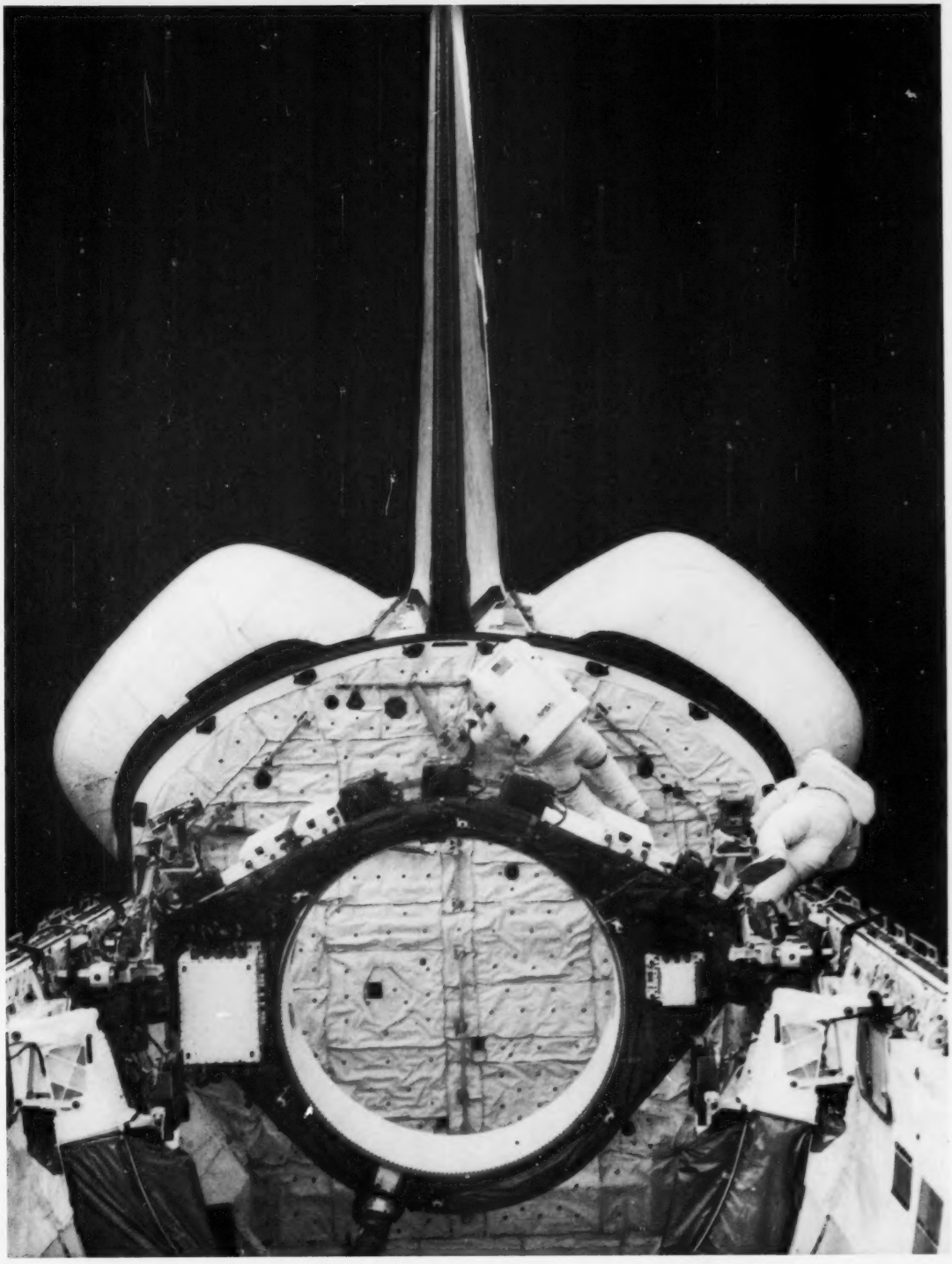


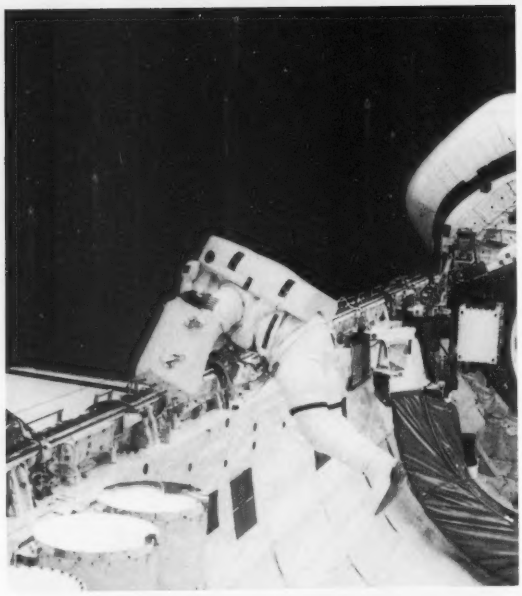


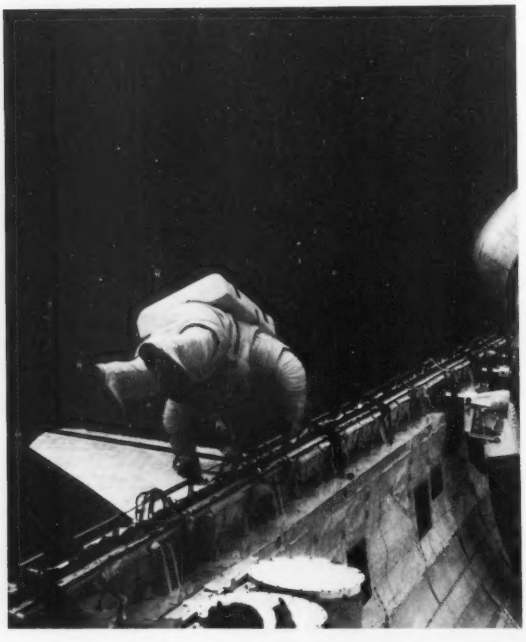


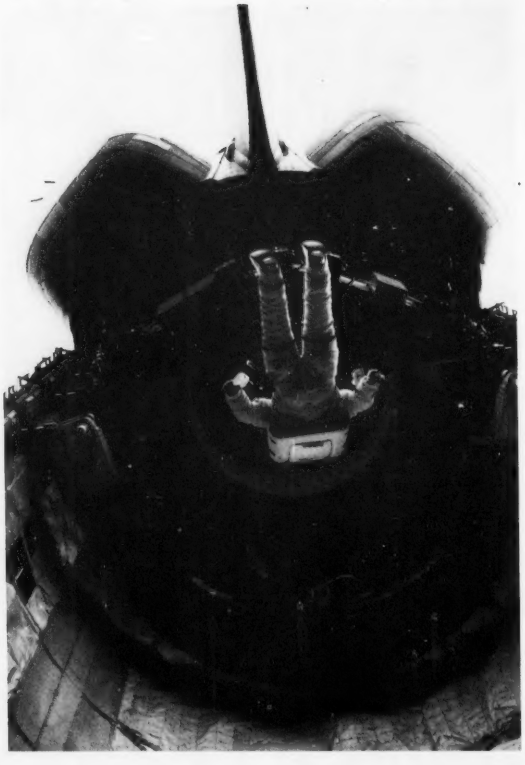
Deployment of the major cargo for Shuttle Flight 6—the TDRS-A (for Tracking and Data Relay Satellite)—on flight day one, at approximately 11:31 p.m. EST. The spacecraft was deployed at approximately 240 kilometers (150 miles) altitude. Top left photo, taken through the Shuttle aft flight deck windows, provides a good view of the satellite's rocket booster, the Air Force-developed IUS (for inertial upper stage), marked with the USA emblem. Top right frame shows Sun-reflected view of TDRS-A's folded solar panels and antenna systems as the spacecraft leaves the cargo bay. Diagram at bottom right illustrates nominal deployment sequence. An IUS failure in the second stage burn placed TDRS-A in an elliptical orbit, several thousand miles from its planned geosynchronous orbit of 35,890 km (22,300 miles) above the Earth's equator. NASA plans to utilize TDRS-A's thruster system to move the spacecraft back to geosynchronous orbit, a maneuver that will take approximately two weeks to complete.

Another historical first for NASA as Space Shuttle astronauts perform the first EVA (extravehicular activity) during a Shuttle mission on flight day 4 of mission 6. Mission specialists Story Musgrave and Donald Peterson completed 3½ hours of planned activities in and around the cargo bay area of the orbiter that included work site evaluations, translation and transfer exercises, winch operations and tool box operations. Above a heavily clouded Earth serves as a backdrop for astronaut Musgrave working near the IUS support equipment tilt table.





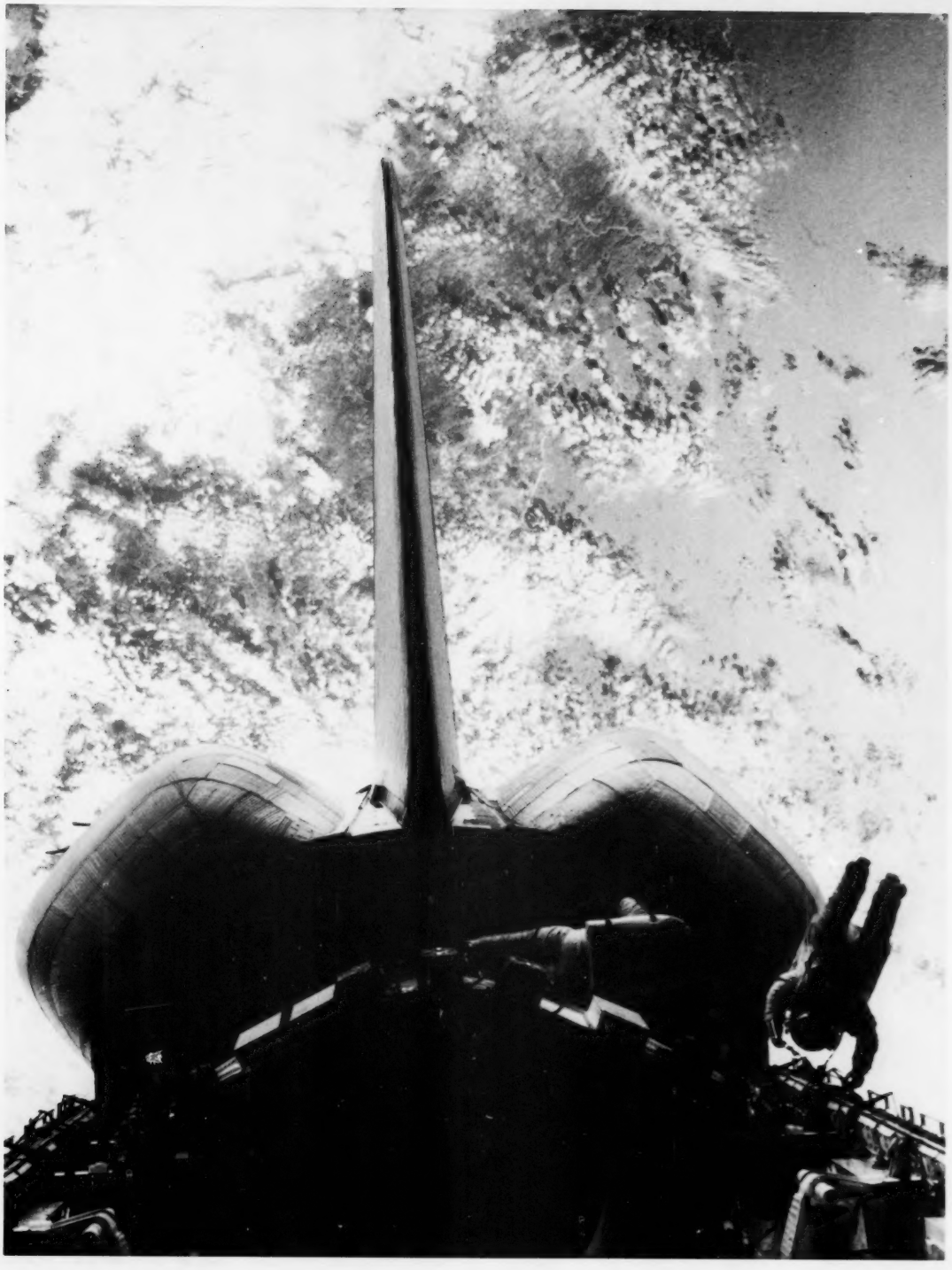




More EVA Activity—Astronaut Story Musgrave performs translation (movement) exercises. At top left he traverses the entire 60-ft. length of the cargo bay using the hand rail system and carrying a bag of latch tools. In bottom left frame he performs this maneuver without the tool bag.

At top right, close-up of Musgrave in EVA suit, participating in safety tether checkout. Musgrave's suit was marked with striped bands on the legs to distinguish him from astronaut Donald Peterson during the pair's EVA exercises.

At bottom right, Musgrave suspends himself midway between the starboard and port slide wire systems to evaluate the pull strength of the safety tether.



Challenger's vertical stablizer and OMS pods frame a portion of Mexico's state of Jalisco below, while astronaut Story Musgrave (left) and Donald Peterson, perform EVA maneuvers (p. 15).

First landing of Space Shuttle Challenger on hard surface runway 22 at Edwards Air Force Base, Calif., on Saturday, April 9, at 1:53 p.m. EST. First flight performance of Challenger was heralded as exceptional in every respect.

One of the final pictures taken aboard Challenger's maiden flight (bottom right)—a 35-mm frame of runway 22 at Edwards Air Force Base, Calif., snapped seconds before the spacraft was lined up for its first landing.

NASA College Scholarship Fund

Noted author James Michener has established a NASA college scholarship fund through an endowment based on proceeds from his book, "Space." Those eligible include qualified dependents of NASA and former NASA employees agencywide. The deadline for applications for the program's first year closes May 6.

The NASA College Scholarship Fund, Inc., is a non-profit corporation, incorporated under the laws of Texas on Oct. 20, 1982 "to receive contributions and to use those contributions and/or income thereof exclusively for charitable, educational, and scientific purposes—such as the awarding of college scholarships to full-time students who are dependents of current or retired NASA employees and dependents of current reimbursable detailees of NASA." In addition, the charter provides that scholarships may be awarded to full-time students who are former dependents of NASA employees or former reimbursable detailees to NASA who died in the line of duty for NASA.

Two scholarships will be awarded for $1,500 each for the 1983-84 school year, the initial year of the program. Applicants must be pursuing a course of study that will lead to a recognized undergraduate degree at an accredited college or university in the United States. Additional scholarships are expected in future years. The renewable scholarship cannot exceed $1,500 per dependent per academic year to a maximum of $6,000 over six calendar years.

In order to be eligible for the scholarship, all applicants must, in addition to the NASA dependence requirements, be graduated properly from an accredited public, private, or parochial high school or be currently enrolled in college with good academic standing. An applicant must have a combined high school grade and college (if any) grade point average of 2.5 on a 4.0 scale or the equivalent.

Applicants who are dependents of current or retired NASA employees must be dependents of employees who are actually employed by NASA for a period of two years as of January of the scholarship year. There is no minimum period of employment requirement for eligible dependents of former NASA employees or former reimbursable detailees to NASA who died in the line of duty for NASA.

A dependent under this program is defined as a student who is currently lawfully claimed as a dependent on his or her Federal income tax return by a current NASA employee or a retired NASA employee or as a student who was lawfully claimed at the time of death on his or her Federal income tax return by a former NASA employee or former reimbursable detailee to NASA who died in the line of duty for NASA.

After meeting the minimum requirements, applicants will be ranked based on the following objective standards:

- academic preparation, including high school grades, any college grades, high school graduating class rank, and pattern of courses;
- school activities;
- community activities;
- performance on recognized tests designed to measure ability and aptitude for high education, such as the Scholastic Aptitude Test or American College Test;
- written recommendations from instructors or other knowledgeable individuals not related to applicant (limit of 3); and
- one-page statement of academic purpose by applicant.

Scholarship funds must be used exclusively for educational purposes—the actual and direct expenses of attending an accredited college or university in the United States. Compliance will protect the non-profit and tax exempt status of the corporation and ensure the availability of future scholarships.

Principal contacts for the NASA College Scholarship Fund, Inc., at the NASA centers are as follows: Headquarters, Ann M. Trotta, code NHP-32; Ames, Louis Schiff, code 227-8; Dryden, Karl Anderson, code EED; Goddard, Dick Stonesifer, code 902; Johnson, Leslie Sullivan, code BE; Kennedy, George English, code EX; Langley, Jess Ross, code 180-A; Lewis, Harold Wharton, code 3-9; Marshall, Benny Cavaliere, code AP-40; National Space Technology Laboratories, Roy Estess; and Wallops, James Floyd, code 1040. Each of these center Exchange officers can supply application forms and answer questions on the program.

All application forms, transcripts, test scores or materials must be mailed in a sealed envelope directly to:

SES/Scholarship Committee
NASA College Scholarship Fund, Inc.
Johnson Space Center
Houston, Texas 77058.

All applications and attached grades or scores must be received by the committee no later than May 6, 1983. All late applications will be returned. Applications will be evaluated by the scholarship committee and top candidates selected. All applicants will be notified by mail by approximately June 10, 1983.

Japanese to Build Full-Scale Model of Space Shuttle

Japan plans to build a full-scale model of America's Space Shuttle ready for display at "The Great Space Shuttle Exhibition" in Tokoyo from June 23 through Sept. 15. The core used to build this model, on loan from NASA, is a Space Shuttle simulator used as a pre-Enterprise checkout vehicle at Marshall Space Flight Center, Huntsville, Ala.

The simulator, sometimes known as the "Pathfinder" vehicle (tagged orbital vehicle number 098), was constructed at Marshall in 1977 as a stand-in for the orbiter Enterprise. The vehicle was used in extensive ground testing at the Center and is nearly the same size and weight as the Space Shuttle Enterprise.

In exchange for the loan of the Pathfinder and for exclusive first exhibition of the completed model, Japan has agreed to be responsible for all refurbishment costs, insurance, and transportation to Japan and return to the United States. NASA will work closely with Japan to ensure the finished product meets acceptable criteria for display. At the close of the exhibition in Aug. 1984, the full-scale mock-up will be returned to NASA.

The Pathfinder model is to be displayed in the No. 1 Pavilion of The Great Space Shuttle Exhibition, entitled "Space Age Today," which will feature the history of peaceful uses of space and Space Shuttle technology. The completed model will be designed as an exact exterior replica of a Space Shuttle. Its construction will be modular to facilitate handling and transportation. The cost of construction and transportation of the full-scale model will be borne entirely by Japan.

The Japanese hope the Pathfinder will join other large scale space artifacts in Pavilion No. 1 currently being negotiated for loan: the Apollo Lunar Landing Vehicle (life size simulator) and Apollo Lunar Command Module (from Apollo 11 or 17). A model of a Space Shuttle main engine is also planned for display.

As a test article for Space Shuttle Enterprise, the Pathfinder was put through rigorous fit-check procedures. In late 1977, Marshall crews loaded Pathfinder onto a special orbiter movement trailer to check clearances along the roadways the Enterprise would travel on the same trailer.

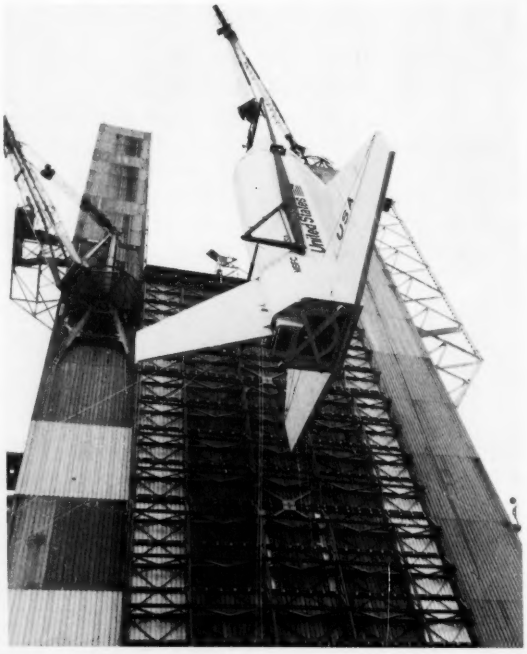
In late 1977, the Pathfinder was hoisted to the top of Marshall's 400-foot tall Dynamics Test Stand and lowered down inside this building for a "fit" test. Enterprise was later placed in this facility, mated to an external tank and solid rocket boosters, for more than a year of dynamic tests.

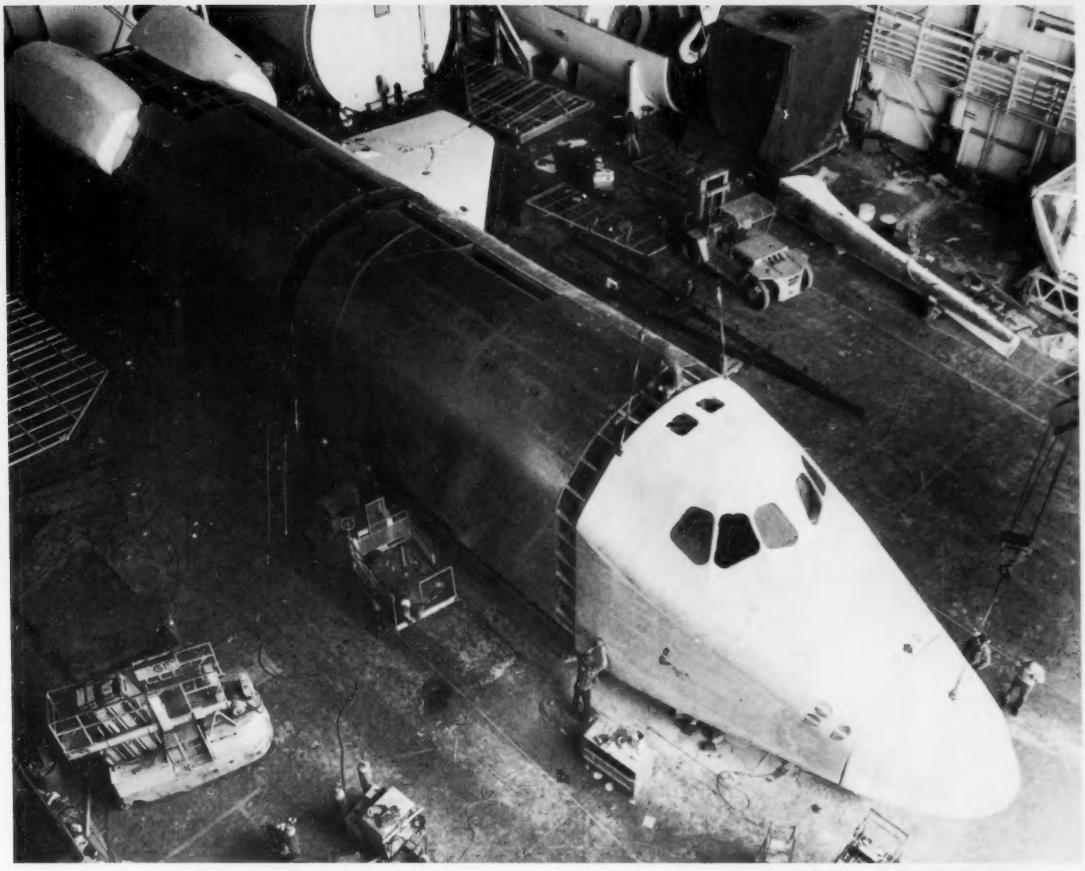
The Pathfinder also was used in Huntsville to check out the hoisting system that would be used to remove Enterprise from the back of its carrier aircraft. The same hoisting system was later used at White Sands, N. M., to mate the orbiter Columbia to its Boeing 747 Shuttle carrier aircraft after a landing at that backup site.

In mid 1978 the Pathfinder was shipped by barge to Kennedy Space Center where is was used in facilities fit checks in the Orbiter Processing Facility, Vehicle Assembly Building, Mate-Demate Device and for ground crew training. The simulator also was used to verify extensive modifications to work platforms in the Vehicle Assembly Building.

In early 1979, Pathfinder enabled ground personnel to rehearse post-landing procedures at Kennedy's three-mile-long Shuttle runway. Later that year, the simulator was returned to Marshall.

Ceremonies initiating the loan of Pathfinder to Japan were held at Marshall on April 22. J.A. Bethay, Executive Assistant to the Director of Marshall and Robert E. Lindstrom, Manager, Shuttle Projects Office, were the senior NASA representatives at the ceremony. Japanese representatives included Masaru Ogawa, executive director of the American-Japan Society; Dr. Yahuhiro Kuroda, chairman of the Great Space Shuttle Organizing Committee; Mrs. Ichiko Ishihara, executive





Space Shuttle simulator used as a pre-Enterprise checkout vehicle at NASA's Marshall Space Flight Center undergoes modifications; this model will serve as the core for a full-scale modular model of a Space Shuttle to be built by the Japanese. At left, the simulator is hoisted into Marshall's giant dynamic test stand for "fit" tests conducted during Dec. 1977.

director, Takashimaya Co., as well as numerous journalists and broadcast representatives.

The Great Space Shuttle Exhibition is cosponsored by the American-Japan Society and the Takashimaya Department Stores, endorsed by the Japan Science and Technology Agency and the Japan Ministry of International Trade and Industry. Other Japanese agencies cooperating in this effort include the National Space Development Agency, Institute of Space and Aeronautical Science and the Chuo Ward Office.

United States agencies cooperating with Japan on "The Great Space Shuttle Exhibition" include NASA, Alabama Space and Rocket Center, Huntsville; and Teledyne Brown Engineering, Huntsville. The exhibition opens June 23 in Tokyo and runs through Sept. 15. It will then be moved to Osaka, Japan, for final display from Oct. 8, 1983 through Jan. 31, 1984. Plans are being made to display the orbiter in two additional cities in Japan during the period of Jan. 11 through August 31, 1984.

NASA Exhibits at the Hanover Trade Fair

NASA presented an exhibit on the potential industrial uses of the Space Shuttle at the Hanover Trade Fair, April 13-20, in Hanover, West Germany. The purpose of NASA's exhibit was to stimulate interest among senior representatives of West European industry in

utilizing the NASA Space Transportation System to explore the industrial uses of outer space.

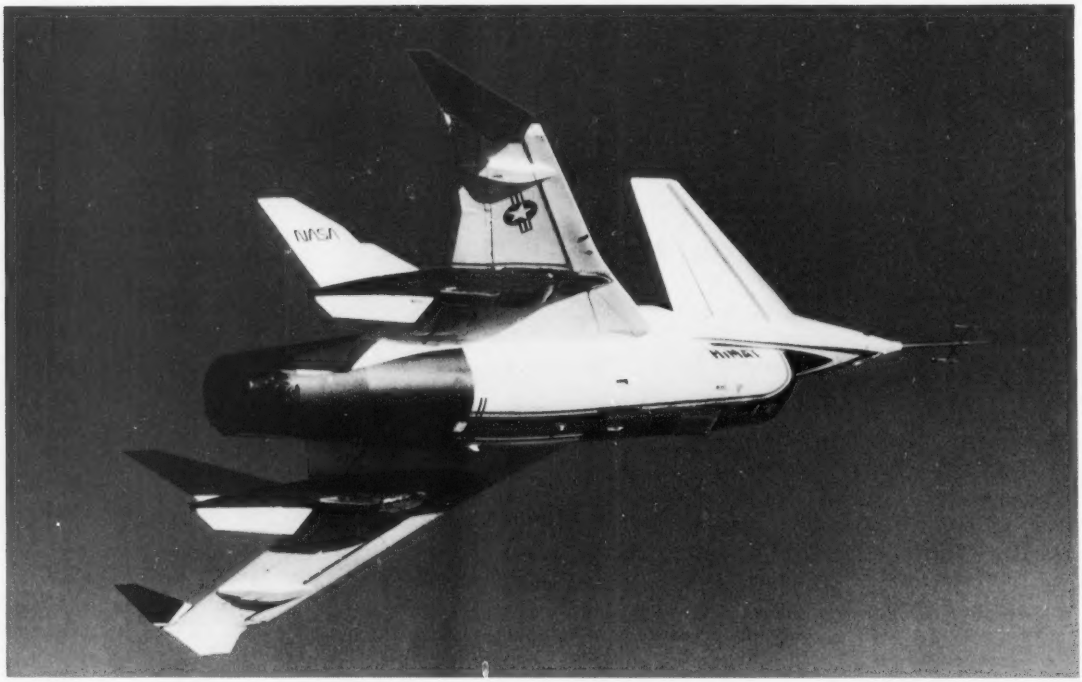
NASA joined 52 countries exhibiting at Hanover on the most recent development in technology. This is the first time that NASA has participated in the Hanover Fair, the world's largest industrial trade fair. In 1982, the fair attracted over 600,000 visitors from 118 countries.

The NASA exhibit informed senior European decision makers, involved in advanced planning and research, about opportunities for experimentation on the Space Shuttle and Spacelab in such areas as biology, medicine and materials science and processing. The exhibit included actual demonstrations of hardware like that already flown aboard flights of the Space Shuttle orbiter Columbia such as a demonstration unit of the McDonnell Douglas Corporation Continuous Flow Electrophoresis System used aboard recent Shuttle flights for the separation of biological materials in micro-gravity.

An engineering model of a Japanese Small Self-Contained Payload (Getaway Special) was displayed. This Payload was used for experiments in crystal growth in micro-gravity aboard the sixth flight of the Space Shuttle in early April. A working prototype of a multi-purpose electric furnace which will fly on future Space Shuttle missions also was demonstrated. Also on display was a working model of an acoustic levitation device of the type used for space materials processing.

NASA experts were on hand throughout the fair to demonstrate the hardware and to provide information on space materials processing activities in the United States. Senior officials from the Office of Customer Services of NASA's Office of Space Flight also were available for individual consultations regarding industrial use of the Space Shuttle and Spacelab.

In addition to the exhibit, two symposia on the industrial uses of the Space Shuttle were held during the fair. The symposia, which included speakers from the United States and West Europe, was co-sponsored by NASA and the West German Federal Ministry for Research and Technology (BMFT). The speakers covered such topics as space materials processing and industrial opportunities aboard the Space Shuttle and Spacelab.



HiMAT (for Highly Maneuverable Aircraft Technology) in flight. The HiMAT test crafts were built by Rockwell at approximately one-half scale size of potential future fighter aircraft and were flown by remote control.

A Look Back at HiMAT

In January NASA brought to a close a joint NASA/Air Force flight test program called HiMAT (Highly Maneuverable Aircraft Technology). Twenty-six flights were completed during the 3½-year program, designed to validate advanced technologies which could lead to future fighter aircraft with twice the maneuverability performance of current fighter aircraft and production of vehicles lighter and less costly than current operational types.

Two HiMAT test crafts, built by Rockwell International, were unmanned remotely piloted research vehicles, air-launched from a B-52 carrier plane and flown by remote control by a pilot from a ground cockpit at NASA's Dryden Flight Research Facility, Edwards, Calif. The HiMAT concept allowed high-risk testing without risk to human life and reduced vehicle costs associated with provisions for pilot occupancy and safety. The research models were built at approximately one-half scale size of a potential lightweight low-cost future fighter.

During the course of the program, HiMAT attained the ability to make transonic turns nearly twice as tight as any current front-line fighter. HiMAT also provided research data on a wide variety of high performance aircraft technologies such as the use of composites, aeroelastic tailoring, and close coupled canards and winglets.

The 3,400-lb. HiMAT (of which 30 percent of its structural weight was in composites) was launched at approximately 45,000 feet from a B-52 aircraft over Dryden. Powered by a General Electric J85-21 afterburner equipped engine, a ground pilot put the craft through maneuvers capable of Mach 1.4 (1.4 times the speed of sound) at 40,000 feet altitude in maximum afterburner for more than 3½ minutes. At top cruise speeds, greater than .6 Mach, HiMAT flew research missions in excess of one hour. HiMAT landed on Edwards dry lakebed on skids, much like the system used by Rockwell on the X-15 research aircraft. Approach speed ranged from 219-230 mph (190-200 knots), and touchdown speed approximated 167 mph (145 knots) with a 549-meter (1,800-foot) slideout.

The aerial television system used in NASA's F-15 RPRV (Remotely Piloted Research Vehicle) program was used in HiMAT. The camera, mounted in the cockpit area, gave the ground pilot limited outside view through the canopy windshield which aided in approach and landing.

Backup pilot control was provided by a TF-104G chase aircraft. Flight control avionics operated in three modes. The primary control link originated from the ground facility with onboard systems relaying uplink instructions to the craft's controls system actuators. In the second mode, provided in the event ground control was lost, simple command inputs could be provided by the TF-104G pilot to the autopilot onboard the HiMAT.

The third mode was designed for short-term use only in the event ground control was lost and the chase plane was too far away from HiMAT to control it. In this instance, HiMAT's onboard autopilot system could have brought the vehicle to a wings-level flight and then into a 30 degree orbital flight at a constant subsonic speed, allowing the chase plane to approach and take over control.

Of HiMAT's total structural weight, about 20 percent was graphite; 3 percent, fiberglass; 26 percent, aluminum; 18 percent, titanium; 9 percent, steel; 4 percent, sintered tungsten; and 14 percent, miscellaneous substances such as paint, bonding material, etc. Skin on the fuselage, wing, canard, engine inlet, and vertical stabilizers and wing and canard spars were graphite. Outboard wing leading edges were glass fiber.

HiMAT for the first time explored the property of advanced composites called "unidirectional stiffness." Both the wing and canard were aeroelastically tailored to enhance the aerodynamic characteristics critical to fighter maneuverability—orienting the composite plies to control the change of the airfoil shape under load as a function of the wing and canard bending. A favorable airfoil shape was thus attained in terms of lift and drag for specific conditions.

HiMAT's test design was modular which, for future fighter aircraft, could permit later modifications to new design configurations at minimum cost. The core vehicle contained the engine and all basic flight subsystems. All other configurations were modular. Interchangeable items included the afterburning exhaust module; inlet module; outboard wing; wing and canard leading edges, canard, tip fins, and vertical tail and boom assembly. Replaceable items included the aileron, elevon, elevator, rudder, canard flap and landing gear.

NASA has no immediate plans to refly the HiMAT vehicles. During the course of the program they demonstrated superb performance with maneuverability equal to or above the goals of the design. Analyzed flight data will be reported in a symposium in spring 1984. NASA civilian research pilots for HiMAT were Bill Dana, Steve Ishmael and Einar Enevoldson.

NASA's Participation in the 1983 Paris Air Show

NASA will continue in 1983 its over two-decade history of participation in the world's largest aerospace trade exhibition, the Paris Air Show. Held every two years since 1909, the 1983 exhibition, scheduled from May 27 to June 5 at Paris' Le Bourget Airport, will feature exhibits or trade participation from approximately 800 companies from over 25 countries. On exhibit will be aircraft and helicopters; engines and missiles; airborne, mechanical and electronic equipment and components; airport equipment; and displays from many research and development organizations.

NASA's participation will include a 5,000 square-foot three-part exhibition in the U.S. Pavilion, flight demonstrations of the Quiet Short-Haul Research aircraft; appearance by several NASA astronauts; and participation in the Second Biennial International Aerospace Symposium held concurrently with the Paris Air Show.

In an agency first for the Paris Air Show, NASA will participate with a strong marketing effort. Located in the business portion of the U.S. Pavilion, with access restricted to credentialed press and aerospace trade participants, NASA will have a marketing team ready to provide comprehensive payload information to potential payload customers for the Space Shuttle.

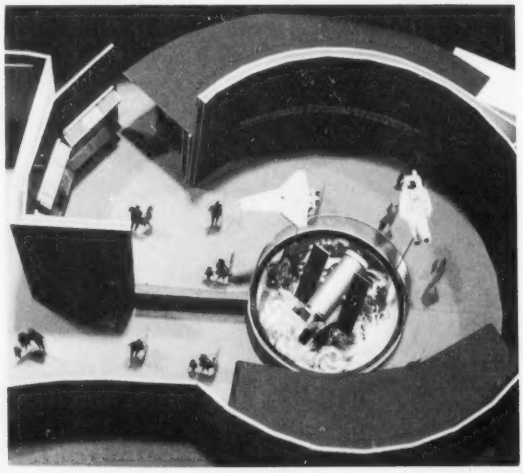
Sophisticated computer programs have been developed that will enable NASA marketing representatives to compute, within seconds, such information as the cost of flying a particular customer's payload aboard the Shuttle, the earliest available launch date for that payload, and depending upon the payload size and requirements, whether the customer would qualify to fly a payload specialist for the mission. Cost comparisons for launch aboard expendable vehicles versus the Space Shuttle also will be supplied upon request.

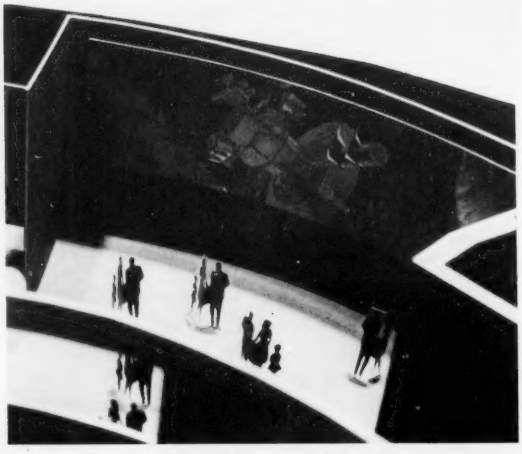
NASA participates in the Paris Air Show through formal request of two U.S. agencies: the Department of Commerce, which coordinates all U.S. activities at the Paris Air Show, and the Department of State, which officially endorses U.S. participation in the exhibition. U.S. participation in the Paris Air Show serves several important purposes:

- to convey to the world aerospace trade that our nation's technology in aeronautics and aerospace is foremost in engineering and development;
- from a marketing standpoint, to ensure domestic and foreign buyers that American equipment and services are technologically reliable and at the forefront of development of that technology.

NASA's 1983 exhibition in the U.S. Pavilion at the Paris Air Show is the only exhibit in the pavilion open to the general public and will feature three sections. An estimated 400,000 people are expected to view NASA's exhibit during the show's 10-day duration.

Visitors will enter the exhibit area through a long hallway which is section one of the exhibit entitled "Exploring the Solar System." Featured will be still photos, slides and video tapes of NASA's past, present and future programs of solar system exploration. Included in this collection will be Viking's mission to Mars, Pioneer Jupiter and Venus missions; Vogager's journeys to Jupiter and Saturn, data from the High





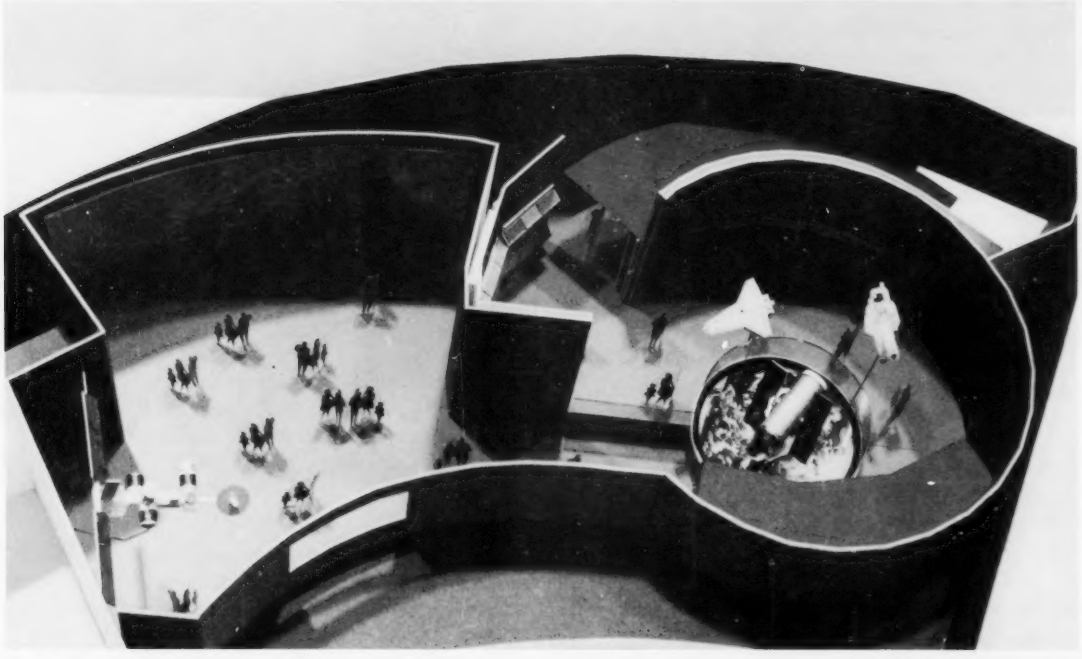
Energy Astronomical Observatory and, looking forward to the mid 1980s, Space Telescope and Galileo's mission to Jupiter.

Once visitors pass through the hall, they enter the second phase and central portion of the exhibit entitled, "Going to Work in Space." This section will be devoted to displays showing various uses of space made possible by the advent of the Space Shuttle. Viewers walk through this exhibit area on an elevated circular platform which is above and encircles a large global model of the Earth; suspended in the air above the Earth will be models of the Space Shuttle and Space Telescope.

Exhibit units on display will include a model of an electrophoresis experiment; a space furnace model demonstrating a metals melting experiment; and materials processing/manufacturing experiments. This section of the NASA exhibit also will feature a multi-image audio-visual presentation on the versatility of the Space Shuttle such as launching communications satellites, transporting materials for constructing large structures in space, and experiments on planetary/Earth/Sun relationships. As the public leaves this part of NASA's exhibit, they will enter the third and final section—a stand-up theatre entitled the "Future in Space." This unique section will feature a realistic look forward to our nation's future in space, derived from actual engineering feasibility studies conducted by NASA and other organizations interested in the exploration of space.

On a huge viewing screen, an audio visual presentation will feature a progression of future activities in space: from astronauts assembling a space station in low Earth orbit to manned and unmanned use of the orbital transfer vehicle; onward to construction of large space modular structures and solar collectors to building space stations in geosynchronous orbit with modifications of the Shuttle as a larger cargo carrier or space derrick.

From geosynchronous orbit, the presentation continues with further lunar exploration and colonization of the Moon, to exploitation and use of its resources. The next step presented is an unmanned mission to Mars utilizing a crawler vehicle and then onward to a manned outpost on the red planet.



Artist cutaway view of NASA's Paris Air Show exhibit. At top center, visitors enter the 5,000-square-foot exhibit from a hallway entitled, "Exploring the Solar System." This hallway leads into the second phase or central portion of the exhibit entitled, "Going to Work in Space." Hovering above a model of the Earth are models of the Space Shuttle, Space Telescope, and an astronaut's spacewalk suit or EMU (extravehicular mobility unit). From this section, viewers enter the final section of the exhibit—a stand-up theatre entitled "The Future in Space." At left (p. 22), are close-up views of the second and final sections of the NASA exhibit.

Many of the slides in this presentation are taken from NASA's Space Shuttle art collection that illustrates various types of space exploration and utilization within the next several decades.

The final phase of the "Future in Space" exhibit features the evolution of permanent space habitation, with colonies established on a three-planet base—the Earth, the Moon and Mars—complete with independent power generation, mining and manufacturing capabilities.

On runway display and scheduled for demonstration flights will be NASA's Quiet Short Haul Research Aircraft (QSRA), an experimental aircraft that demonstrates technology useful in solving two major aviation problems: aircraft noise and airport congestion.

QSRA, managed by NASA's Ames Research Center, Mountain View, Calif., and built by Boeing Commercial Airplane Co., features an innovation known as propulsive lift: engine exhaust is deflected downward over the wing surface to increase aircraft lift thereby permitting QSRA to climb and descend at steep angles, fly safely at very low speeds, and operate from shorter runways than required by conventional long-haul jetliners.

QSRA's engines are soundproofed to muffle internal noise; external noise also is reduced because the aircraft's engines are mounted above the wing—a design that uses the wing to block the noise and divert it upward away from the "eardrum" zone below.

These capabilities support the use of short takeoff and landing aircraft from separate, small, close-to-city airports, which could help alleviate congestion at major hub terminals.

Concurrent with the Paris Air Show is the Second Biennial International Aerospace Symposium from May 31 to June 1, also held at Le Bourget Airport. The symposium is sponsored by the U.S. Department of Commerce, the Federal Aviation Administration, NASA and the U.S. Air Force, with cooperation of the Groupement des Industries Francaises Aeronautiques and Spatiales and the Association Aeronautique et Astronautique de France, and organized by the American Institute of Aeronautics and Astronautics. The symposium will feature four sessions: commercial aviation, military aircraft, space operations, and space research and development.

NASA participants in the symposium will include Administrator James M. Beggs; Jack L. Kerrebrock, Associate Administrator for Aeronautics and Space Technology; Noel Hinners, Director of Goddard Space Flight Center, Greenbelt, Md.; James A. Abrahamson, Associate Administrator for Space Transportation Systems; and NASA astronaut Bill Lenoir, mission specialist from Shuttle flight five last November.

What's New in NASA Television and Radio Programming

Programs released in April (and May for television):

Television:
Aeronautics and Space Report (4½ minutes)
Space Shuttle: Flight Six (April)
Aeronautics and Space Report—Two part series (4½ minutes)
NASA's ET (May)
Pioneer 10 Leaves the Solar System (May)

Radio:
Houston, We Have a Problem . . . (14½-minute monthly report; featuring astronauts James Lovell and Fred Haise)
Second Anniversary Space Shuttle 1 (4½-minute weekly report; featuring Neil Hutchinson, Johnson Space Center)
Radar Discovers Hidden Features (4½-minute weekly report; featuring Dr. Charles Elachi, Jet Propulsion Laboratory)
Pioneer Pluges Into Interstellar Space (4½-minute weekly report; featuring Dr. Palmer Dyal, Ames Research Center)
Spacelab's First Flight (4½-minute weekly report; featuring Harold Craft, Marshall Space Flight Center)
Space Notes (1 minute each):
Lunar Rocks Found on Earth
AXAF . . . A Look into the X-Ray Sky
Pioneer Leaves the Solar System
Search and Rescue Satellite
Dramatic New Discoveries with IRAS
Space Telescope . . . Our Eyes to the Universe
Enhanced Images Aid Search for 1813 Vessels
Cosmic Background Explorer
Laboratory in Space
Project Condor . . . Rocket Experiments in Peru

Copies of television tapes are sent simultaneously to all NASA Visitor Information Centers and Public Affairs Offices, and to 650 television stations nationwide as well as to 425 cable television systems via the satellite SATCOM III. Five hundred television stations receive material formatted as a 4½-minute program; the remaining 150 stations receive a 90-second "spot"—a condensed version of the 4½-minute presentation.

NASA's radio programs are sent to over 2,000 radio stations across the nation; in addition, translations of the recordings are made by Voice of America and Radio Free Europe and these tapes are then released to the appropriate audiences overseas. Released each month are one report of 14½ minutes and four 4½-minute weekly stories (one story in the set is featured for one week of the month). Ten 1-minute space notes are released quarterly.

Space Station Update

In recent weeks, NASA has accepted 18 proposals for studies that may lead to innovative uses of a future space station and, in a separate proposal, President Reagan has requested the Senior Interagency Group for Space to conduct a study to establish the basis for an Administration decision on whether to proceed with NASA development of a permanently-based, manned space station.

The 18 studies, funded for a total cost of $400,000 by NASA's Office of Space Science and Applications, are an attempt to get new ideas for consideration in designing a space station. This is in line with NASA's desire to involve space station users early in the planning process so that user requirements will be fully considered in the design and construction of hardware.

NASA also has eight industrial studies underway to investigate the requirements for such a station. In addition, internal NASA studies and scientific advisory committee investigations are being considered in NASA's planning effort to define a possible space station.

The 18 proposals accepted by NASA were selected from more than 300 formal proposals received. NASA issued a request for proposals on Nov. 1, 1982, and set a deadline for submission of Jan. 1, 1983. The 18 selected proposals cover a wide range of potential space station uses—life sciences, astrophysics, Earth and environmental sciences, materials processing, artistic potential, new technology development and commercial possibilities. Approximately half the studies will be conducted at universities, one-third by the private sector and the remainder at government laboratories. All studies call for final reports to NASA in September 1983. The 18 proposals accepted are:

Dr. Thomas J. Ahrens, California Institute of Technology, Pasadena, **Orbiting Dynamic Compression Laboratory;**

Dr. Jeffrey R. Alberts, Star Enterprises, Bloomington, Ind., **Mammalian Development and Reproduction During and Subsequent to Null Gravity Conditions;**

Dr. Robert S. Bandurski, Michigan State University, East Lansing, the **Alpha Helix Concept;**

Dr. Alan N. Bunner, Perkin-Elmer Corp., Danbury, Conn., **Optical Coating in Space;**

Dr. Lewis M. Duncan, Los Alamos National Laboratory, N.M., **Study of Requirements for a Space Station Incoherent Scatter Radar;**

James C. Fox, KMS Fusion, Inc., Ann Arbor, Mich., **Study of Robotics Systems Applications to the Space Station Program;**

Dr. Ronald Greeley, Arizona State University, Tempe, **Feasibility Study to Conduct Windblown Sediment Transport Experiments Aboard a Space Station;**

Prof. Herman H. Hobbs, George Washington University, Washington, D. C., **Terrestrial Whisker Growth Experiments Which Anticipate some Special Effects of a Space Station Experiment;**

Dr. Bruce A. Houtchens, University of Texas Health Science Center, Houston, **System for the Management of Trauma and Emergency Surgery in Space;**

Dr. David G. Koch, The Center for Astrophysics, Smithsonian Astrophysical Observatory, Cambridge, Mass., **Large Area Gamma-Ray Imaging Telescope System;**

Dr. Koichi Masubuchi, Massachusetts Institute of Technology, Cambridge, **Feasibility of Remotely Manipulated Welding in Space, a Step in the Development of Novel Joining Technologies;**

Dr. F. Curtis Michel, William Marsh Rice University, Houston, **Analog Magnetospheric Physics Simulations from a Space Station;**

Dr. Gregory A. Nelson, Jet Propulsion Laboratory, Pasadena, **Novel Approach to the Study of Developmental Biology in Space;**

James S. Pridgeon, University of Washington, Seattle, **Artistic Potential of the Space Station Program;**

Dr. Robert Stachnik, The Center for Astrophysics, Smithsonian Astrophysical Observatory, Cambridge, **Study of Space-Station-Associated Multiple Spacecraft Michelson Spatial Interferometer;**

Dr. Robert E. Turner, Science Applications, Inc., McLean, Va., **Proposal for the Measurement of the Atmospheric Aerosol Content from a Space Station;**

Donn C. Walklet, Terra Mar, Mountain View, Calif., **Alternative Strategies for Space Station Financing;** and

Dr. William J. Webster Jr., Goddard Space Flight Center, Greenbelt, Md., **Measurement of Earth's Magnetic Field at High and Extremely Low Altitude Using Space Station-Controlled Free-Flyers.**

In response to the President's request, the Senior Interagency Group, chaired by the Assistant to the President for National Security Affairs, William P. Clark, will consider four example scenarios of possible approaches for the continuation of this nation's manned space program, following completed development of the Space Shuttle:

- Space Shuttle and unmanned satellites;
- Space Shuttle and unmanned platforms;
- Space Shuttle and an evolutionary space station;
- Space Shuttle and a fully functional space station.

The issues addressed by the study will include how a manned space station would contribute to the maintenance of U.S. space leadership and how a station would best fulfill national and international requirements versus other possible means of satisfying them. Foreign policy and national security implications and overall economic and social impacts will also be considered.

A working group, chaired by NASA and including State and Defense Department and other representatives of the Senior Interagency Group for Space, has been established to conduct this study. Results of the study will be presented to the Senior Interagency Group this fall prior to their presentation to the President.

NASA's 25th Anniversary, Oct. 1, 1983 Historical Calendar for May

May 3, 1977	First flight of XV-15 (tilt rotor)
May 4, 1967	Launch of Lunar Orbiter IV
May 4, 1976	Launch of LAGEOS
May 4, 1979	Launch of FLTSATCOM-B
May 5, 1961	Launch of Mercury Redstone 30 (Freedom 7; A. Shepard, Jr.)

NASA Historical Calendar—continued

May 5, 1967	Launch of Ariel III (UK-E)
May 7, 1959	United Kingdom uses moon to relay signal to United States
May 7, 1963	Launch of Telstar II
May 7, 1975	Launch of SAS-C (Explorer 53)
May 7, 1975	Launch of Telesat-C (Anik 3)
May 8, 1971	Launch of Mariner H (8)
May 11, 1978	Launch of OTS-B
May 11, 1983	First supersonic flight of HiMAT
May 13, 1964	Launch of Little Joe II
May 13, 1976	Launch of COMSTAR-1A
May 14, 1973	Launch of Skylab 1
May 15, 1963	Launch of Mercury Atlas 9 (Faith 7; L. Gordon Cooper)
May 15, 1966	Launch of Nimbus II
May 15, 1981	Launch of NOVA 1
May 17, 1968	Launch of ESRO-IIB
May 17, 1974	Launch of SMS-1
May 18, 1968	Launch of Nimbus B
May 18, 1969	Launch of Apollo X
May 19, 1965	Launch of Little Joe II (# 6)
May 20, 1978	Launch of Pioneer/Venus A
May 22, 1969	Launch of Intelsat III F-4
May 22, 1975	Launch of Intelsat IV F-1
May 22, 1981	Launch of GOES-E
May 23, 1981	Launch of Intelsat V-B
May 24, 1962	Launch of Mercury Atlas 7 (Aurora 7; M. Scott Carpenter)
May 24, 1967	Launch of Explorer XXXIV (34)
May 25, 1961	JFK Apollo Speech
May 25, 1965	Launch of Pegasus II
May 25, 1966	Launch of Explorer XXXII (32)
May 25, 1973	Launch of Skylab 2 (first manned Skylab)
May 26, 1977	Launch of Intelsat IVA F-4
May 28, 1964	Launch of Saturn 1 (SA-6)
May 29, 1965	Launch of Explorer XXVIII (28)
May 29, 1967	Launch of ESRO II-A
May 29, 1980	Launch of NOAA-7
May 30, 1966	Launch of Surveyor 1
May 30, 1971	Launch of Mariner 9
May 30, 1974	Launch of ATS-F (6)

Patents for Inventions from NASA Research

The Office of General Counsel, NASA Headquarters, announces that the following U.S. patents have been issued by the U.S. Patent and Trademark Office to NASA for inventions resulting from NASA research. Inquiries concerning them should be directed to the attention of the NASA Patent Counsel of the indicated installation.

Inventor(s) & Employers	Title	Patent No.	Installation
John C. Evans, An-Ti Chai, and Chandra P. Goradia, NASA/LeRC	High voltage V-groove solar cell	4,376,872	LeRC
George C. Shanks, McDonnell Douglas Corp., Long Beach, Calif.	Compression test apparatus	4,377,089	JSC
Bruce A. Banks, NASA/LeRC	Ion beam sputter-etched ventricular catheter for hydrocephalus shunt	4,377,169	LeRC
Robert R. Belew and Richard J. Boehme, NASA/MSFC	Electrical rotary joint apparatus for large space structures	4,377,266	MSFC
Daryl J. Monson, NASA/ARC	Dual-beam skin friction interferometer	4,377,343	ARC
Donald W. Wisander and Robert C. Bill, NASA/LeRC	Laser surface fusion of plasma sprayed ceramic turbine seals	4,377,371	LeRC

Expendable Launches for 1983

Name	Launch Date	Vehicle	Range	Mission Remarks
*IRAS	January 25	Delta	WSMC	Infrared astronomy. NASA scientific.
*NOAA-E	March 28	Atlas-F	WSMC	NOAA weather and SARSAT. Reimbursable.
*RCA-F	April 11	Delta	ESMC	RCA communications. Reimbursable.
GOES-F	April 28	Delta	ESMC	NOAA weather. Reimbursable.
Intelsat V-F	May 12	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.
EXOSAT	May 26	Delta	WSMC	European Space Agency. Reimbursable.
Galaxy-A	June 16	Delta	ESMC	Hughes Communications, Inc. Reimbursable.
HILAT	June 28	Scout	WSMC	Air Force research and development. Reimbursable.
Telstar 3-A	July 28	Delta	ESMC	AT & T communications. Reimbursable.
RCA-G	August 25	Delta	ESMC	RCA communications. Reimbursable.
NOAA-D	August	Atlas-F	WSMC	NOAA weather. Reimbursable.
Galaxy B	September 22	Delta	ESMC	Hughes Communications, Inc. Reimbursable.
NAVY-21	4th quarter	Scout	WSMC	DOD transit. Reimbursable. Call up.
San Marco D/L	November	Scout	SMR	International cooperative/Italy.
AF-1	December	Scout	WFC	Air Force development program. Reimbursable.
Intelsat VA-A	December	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.

* Successful launch

Space Shuttle Launches for 1983

Orbiter	Launch Date	Launch Number	Launch Site	Payload
*Challenger (OV-099)	April 4	6	KSC	TDRS-A
Challenger (OV-099)	June 9	7	KSC	OSTA 2; SPAS-01 Telesat-F; Palapa B-1
Challenger (OV-099)	August	8	KSC	INSAT 1-B; TDRS-B
Columbia (OV-102)	September 30	9	KSC	Spacelab 1
Challenger (OV-099)	December 14	10	KSC	DOD 84-1

* Successful launch

Another Dividend from Air and Space

Research and development in aeronautics and space have provided numerous benefits for all Americans—and at a tiny percentage of the tax dollar. Here is an example:

Dropproof Handtools

A drop-proof device for tools designed for use by astronauts in the weightlessness of space also could provide valuable assistance for workers here on Earth. In occupations where the loss of a tool would prove to be hazardous or at the least highly inconvenient—such as for divers or scaffold workers—this device, developed by NASA astronaut Bruce McCandless, offers increased safety and a solution to this potential problem.

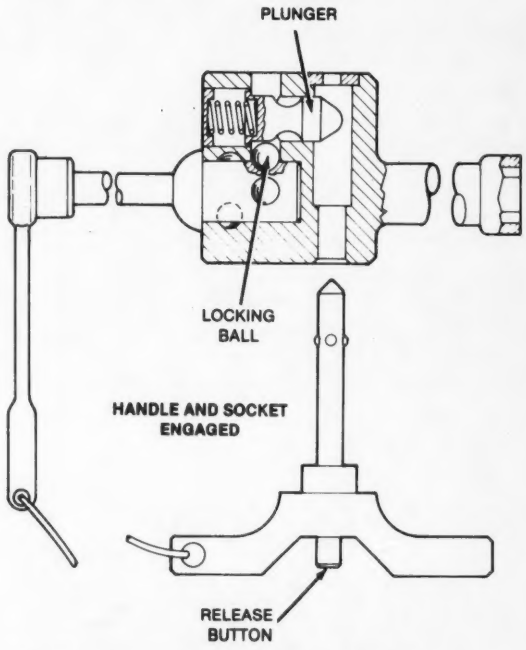
The mechanism can be added to ratchet wrenches and other composite tools for which there is relative motion between the parts. An advantage of the device is that it secures both parts of the tool—for example, a ratchet wrench handle and wrench socket—yet only one tether is attached to the tool while it is being used which does not interfere with the movement of the parts.

The key element of the device, shown in the diagram, is a retaining pin called a "pip pin." The two components of the tool can only be joined together if the pip pin is in place. When the pin is removed, the components become locked together. To separate the components, the pip pin must be reinserted.

As shown in the figure, a ratchet wrench handle is to be attached to a wrench socket. The pip pin is inserted in a drilled passageway wrench socket. Tethers are attached to the handle and to the pip pin but not to the socket. When the two parts of the wrench are disengaged the tether on the handle keeps the handle from being lost if it is dropped; the tether on the pip pin prevents loss of the pin and socket if they are dropped.

After both parts of the wrench are engaged, the pin is extracted as far as possible without releasing the pip-pin ball locks. This lowers a plunger and forces a locking ball to lock the wrench handle in the socket, rendering it impossible to disengage the parts.

The integrity of the lock mechanism may be tested prior to removal of the tethering pip pin from the socket. After verification, the pip pin ball locks are released by depressing its actuator button and



the pin is removed as shown at right in the diagram. The tool assembly is now ready for use. The tether on the wrench handle prevents the wrench from being lost if it is dropped. The pip pin and socket are disengaged if the release button on the pin is depressed while the pin and socket are pulled apart.

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